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Adaptive Computer-Assisted Mammography Training for Improved Breast Cancer Screening

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Table of Contents

	<u>Page</u>
Introduction.....	3
Body.....	3
Key Research Accomplishments.....	7
Reportable Outcomes.....	7
Conclusion.....	7
Appendices.....	7

INTRODUCTION: In this project, we proposed to research the methodology for constructing adaptive computer-aided education systems for mammography. The project includes: Observer studies to collect reading data from radiology trainees; Extraction of image features (human- and computer- based) from mammograms; Statistical modeling of trainees reading data to discover patterns in their error making; Development of methodology for adaptive training that utilizes the constructed models. The proposed adaptive system could improve education in mammography. This may in turn result in improved benefit of mammography in breast cancer detection and lower mortality associated the disease.

BODY:

Overall progress:

Specific aim	Expected	Actual
<i>1.1 Prepare the database of screening mammograms (year 1, months 1-6)</i>	Completed	Completed in respect to the data for the first reader study
<i>1.2 Obtain the approval for the human subject (observer) studies in tasks 1 and 3.</i>	Completed	Completed
<i>1.3 Perform an observer study in which residents will search for masses and architectural distortions (year 1, months 7-9). We expect 20 human subjects (observers) to participate in this study.</i>	Completed	Completed
<i>1.4 Utilize the user data collected in the observer study to develop machine learning-based individual user models (year 1, month 10 – year 2, month 6)</i>	In progress	In progress

The detailed description of progress regarding each specific aim follows.

1.1 Prepare the database of screening mammograms (year 1, months 1-6)

STATUS: completed in respect to the data for the first reader study

DETAILS:

In order to conduct a reader study we had to collect a set of mammographic cases including normal and abnormal cases. This step included securing access to Duke's clinical data for the PI. In order to retrieve cases, we identified a set of potential patients and exams using Duke's informatics system and then analyzed the patient's data, including radiology reports, to find exams that could be used in this study. Then, images were retrieved using PACS system. One hundred digital mammographic cases were used for the first reader study.

DIFFICULTIES:

The mammographic cases were originally proposed to be retrieved from the database of screen-film mammograms (DDSM) available online. This original plan was changed. Since we believe that using digital mammograms instead of screen-film mammograms is more relevant

to the current and future clinical practice, we decided to use digital mammograms for this study. The change was discussed with a DOD program official. This radically increased the time of the data collection since instead of simply downloading the mammograms from an already organized online database, we had to go through an extremely time consuming retrospective data collection process at Duke. Additionally, since the collection of the images involved human subjects, we had to wait for the IRB approval to start collecting the data. While the data collection time was increased, we were able to collect a usable set of digital mammography cases for the first reader study. Additional mammograms will be collected as needed.

1.2 Obtain the approval for the human subject (observer) studies in tasks 1 and 3.

STATUS: completed

DETAILS:

We obtained an approval for the human subject studies. Specifically the approval was secured for (1) retrospective collection of mammograms, and (2) collection of data in reader (observer) studies. The approval was first secured within Duke and then the protocol was approved by the DOD. Following the approval, multiple amendments were introduced to the protocol in the course of this project.

DIFFICULTIES:

Since we decided to include digital mammograms collected at Duke rather than originally proposed online database DDSM (this change was discussed with a program official), the protocol had to include details on the retrospective collection of images. This difficulty was resolved.

1.3 Perform an observer study in which residents will search for masses and architectural distortions (year 1, months 7-9). We expect 20 human subjects (observers) to participate in this study.

STATUS: completed

DETAILS:

For this study a graphical user interface (GUI) was developed. The GUI was developed in the C# programming language using the Microsoft Visual Studio software. The GUI allowed for viewing and marking the mammograms as well as answering the questions related to each case. The GUI software saved the reading data for future analysis.

Monitor and a computer workstation were also purchased using the grant funds.

Subjects for the reader study were recruited from Duke and UNC Chapel Hill. A total of 18 subjects participated in the study. Three of them were breast imaging attendings (as reference data). Out of remaining 15 subjects, 10 provided data that we were able to use in our experiments. The reasons for a subject's data not being usable included misunderstanding of the instructions. Out of the 10 usable subjects, 7 were residents, 2 were researchers and 1 was a medical student. The non-resident participants were included to resemble pre-residency trainees.

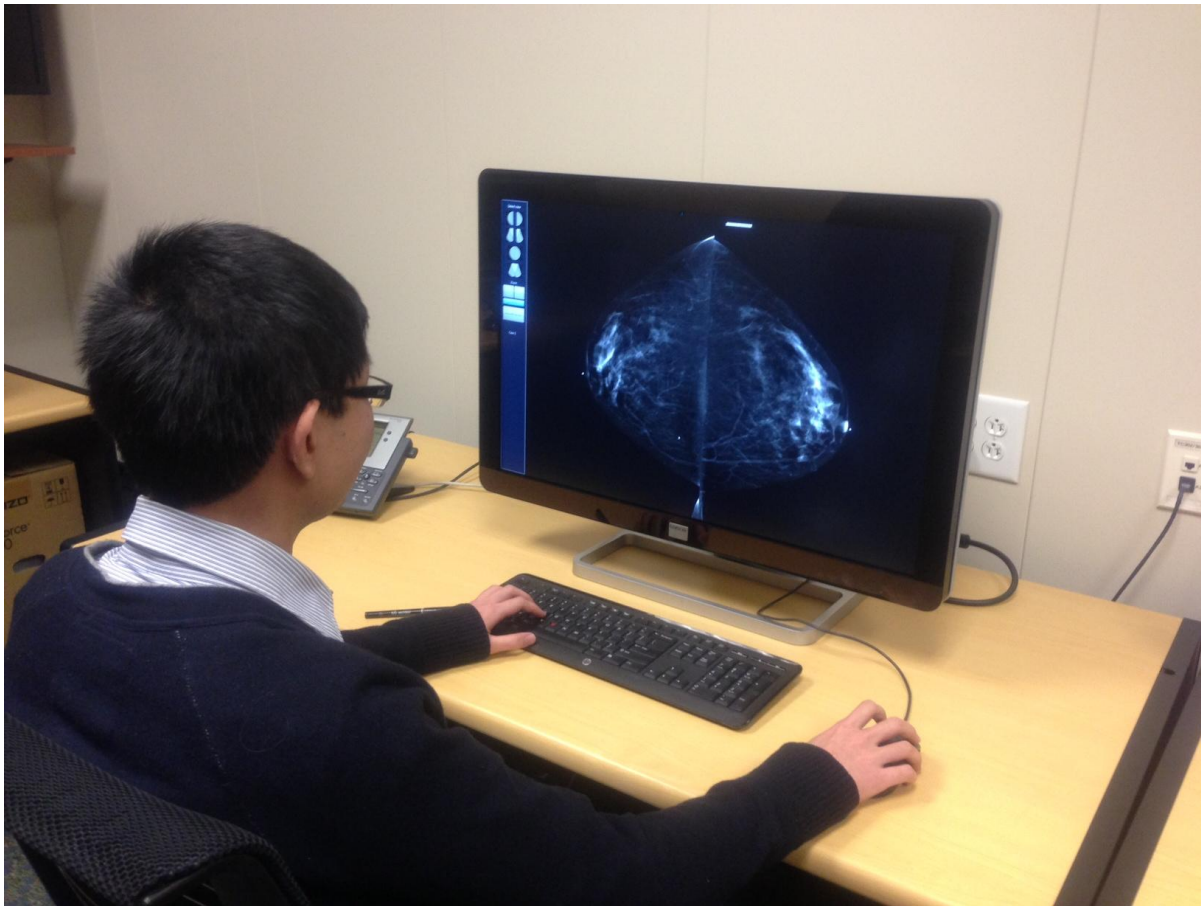


Figure 1 The workstation and the graphical user interface prepared and used for the reader study

DIFFICULTIES:

As the study was time consuming (~3 hours), it has proven difficult to recruit subjects. However, though various recruitment efforts at two medical centers (Duke and UNC Chapel Hill) we were able to recruit a reasonable number of subjects that we can use in our analysis.

1.4 Utilize the user data collected in the observer study to develop machine learning-based individual user models (year 1, month 10 – year 2, month 6)

STATUS: in progress

DETAILS:

This task consists of developing a set of human-extracted and computer-extracted image features as well as utilizing these features to build models that predict how the trainees make errors. We initiated research in this direction.

Specifically, we conducted a preliminary analysis for some of the data collected in the reader studies. Since the focus of our study is on finding cases that are difficult for each trainee, it is important to better understand the concept of case difficulty. We performed analysis that allows for answering questions regarding the relationship between self-assessed difficulty (“subjective” assessment of difficulty) and actual error made for cases (“objective” assessment

of difficulty). The analysis was submitted and accepted to SPIE Medical Imaging 2013 conference and will be published next year (upon submitting the final version of the proceedings manuscript). We will attach the final conference proceedings paper when it is published. The preliminary results showed that there is a notable relationship between the subjective assessment of difficulty, and error (e.g. true positive rate and false positive rate). More detailed statistical analysis is pending.

Furthermore, we are working on constructing a controlled lexicon for extraction of imaging features from mammograms by radiologists. The controlled lexicon is likely to decrease inter-observer variability for the features. I am collaborating with two breast imaging faculty at Duke and one at the UNC Chapel Hill to obtain a comprehensive set of mammographic descriptors that might relate to error in residents.

We also initiated the computerized image analysis step as well as investigated other, related ways of user modeling toward reaching the goals of this study. These analyses are in progress.

DIFFICULTIES:

No major difficulties have been encountered as of this point.

KEY RESEARCH ACCOMPLISHMENTS:

- Secured IRB approval for the study
- Retrospectively collected a set of mammograms for the study
- Conducted an observer study
- Conducted preliminary analysis of the observer study results
- Initiated development of a controlled dictionary for mammography education

REPORTABLE OUTCOMES:

- Collected a database of digital mammograms
- An extended abstract entitled "Difficulty of mammographic cases in the context of resident training: preliminary experimental data" submitted and accepted to SPIE Medical Imaging 2013 conference.

CONCLUSION:

The work proceeds mostly according to the original timeline. Since in the first year, we proposed to mostly focus on preparation to research (IRB approval), collection of images and collection of reader data, no major scientific discoveries are reported yet. However, thorough execution of these first steps is crucial for the success of the entire project.

APPENDICES: No appendices at this time